Bacterial Source Tracking Analyses to Support Virginia's TMDLs

Shellfish Stations

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in cooperation with

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CONTENTS

FIGURES

TABLES

ACKNOWLEDGEMENTS

1. INTRODUCTION

EPA's document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (USEPA, 1999) states:

> *According to section 303(d) of the Clean Water Act and EPA water quality planning and management regulations, States are required to identify waters that do not meet or are not expected to meet water quality standards even after technology-based or other required controls are in place. The water bodies are considered water quality-limited and require TMDLs.*
>
> *. . . A TMDL, or total maximum daily load, is a tool for implementing State water quality standards and is based on the relationship between pollution sources and in-stream water quality conditions. The TMDL establishes the allowable loadings or other quantifiable parameters for a water body and thereby provides the basis for States to establish water quality-based controls. These controls should provide the pollution reduction necessary for a water body to meet water quality standards.*

The purpose of this project is to use bacterial source tracking to identify sources of *E. coli* to support the development of *E. coli* TMDLs for impaired segments in Virginia. In fulfilling the state requirement for the development of a TMDL, a systematic process will be utilized to establish the maximum allowable *E. coli* loading for each waterbody to meet the applicable standard, allocate that load among pollutant contributors, and provide a basis for taking actions needed to restore water quality.

Bacterial Source Tracking (BST) methods can be subdivided into three basic groups: Molecular, Biochemical, and Chemical. Molecular (genotype) are typically referred to as "DNA fingerprinting" and are based on the unique genetic makeup of different strains, or subspecies, of fecal bacteria. Biochemical (phenotype) methods are based on an effect of an organism's genes that actively produce a biochemical response under controlled conditions. The type and intensity of the response is what is actually measured. Chemical methods are based on finding chemical compounds that are associated with

human wastewaters, and generally are restricted to determining if sources of pollution are human or not.

Hagedorn's (Hagedorn et al., 1999) Antibiotic Resistance Analysis (ARA) technique was used for this project because it has been demonstrated to be a reliable procedure for confirming the presence of human, livestock, wildlife and pet sources. Compared to DNA fingerprinting, biochemical profiling is much quicker, typically allows for many more isolates to be analyzed (*e.g.*, hundreds per week vs. a few dozen per week for DNA analysis), is more economical, has survived limited court testing, and has undergone rigorous peer review from the scientific community. Additionally, observation of an increased number of isolates allows for an estimate of the relative proportions of the fecal indicator (*e.g.*, *E. coli*) originating from different sources.

2. OBJECTIVES

BST was used to identify sources of *E. coli*, and the relative percentage contribution from four source groups (*i.e.*, livestock, wildlife, human and pets) to support the development of *E. coli* TMDLs for impairments located throughout Virginia. BST results will be used to improve public awareness of the problem, to improve model calibration/validation of *E. coli* concentrations and to provide a more equitable allocation of loads to source classes. This report presents the results of water quality sampling conducted in Virginia's shellfish producing waters. A companion report, *Bacterial Source Tracking Analyses to Support Virginia's TMDLs Non-Shellfish Stations,* presents the results of sampling conducted in Virginia's non-shellfish waters.

The specific objectives of the project were to:
1. collect fecal samples from known sources in 22 areas (HUCs),
2. use collected samples to develop a known-source library for each impairment area; and,
3. for this report, perform BST analyses on bacterial isolates collected from plates produced by Department of Shellfish Sanitation in order to assess impaired segments. The BST analyses were conducted using the libraries developed for objective 2.

3. METHODS

Hagedorn's ARA method has been extensively and successfully used by MapTech, and separates fecal sources based on patterns of antibiotic resistance in the *enterococci* or *E. coli*. For this study, *E. coli* was the indicator organism analyzed. The premise of ARA is that fecal bacteria from each source (*e.g.*, human, livestock, wildlife, and pets) will have different resistance patterns to the battery of antibiotics and concentrations used in the analysis. Hagedorn's method for *E. coli* tests each isolate on 28 different combinations of antibiotic type and concentration. Confidence in BST techniques is measured by the level of separation of isolates from known sources, represented as the percentage of isolates that are accurately separated into respective source types (*i.e..*, Average Rate of Correct Classification – ARCC). Additional analyses can be applied to test the specificity of the library. These analyses are discussed further in Section 4 of this document. The ARA method, like other methods (*e.g.*, molecular), requires the collection of source samples from feces of known sources to build a source library. Known-source samples from the four source classes were collected, analyzed, and entered into known-source libraries.

3.1 Collection of Known Sources

Known-source samples were collected in twenty-two HUCs associated with fecal-bacteria impaired waters throughout Virginia (Figure 3.1). In HUCs where known-source samples had not previously been collected to support VADEQ's BST program (newly sampled HUCs), a total of 60 samples were collected. In HUCs where known-source samples were previously collected (updated HUCs), a total of 20 samples were collected to update existing libraries. Each set of source samples was distributed evenly between human, livestock, wildlife, and pets (Table 3.1). Specific species within each source category (*e.g.*, deer, raccoon, poultry, beef, etc.) that were selected to represent the sources in each region were identified through field observation, discussion with local stakeholders, and review of available data (*e.g.*, Virginia Agricultural Statistics). From each sample, up to 8 isolates were analyzed using BST to create a known-source library of 480 isolates for each newly sampled HUC, and to increase known-source libraries by 160 isolates in updated HUCs. To date, approximately 2,965 fecal samples have been

collected to support VADEQ's BST program, resulting in over 22,632 isolates analyzed. In total 873 fecal samples were collected for this study, resulting in 5,864 isolates analyzed.
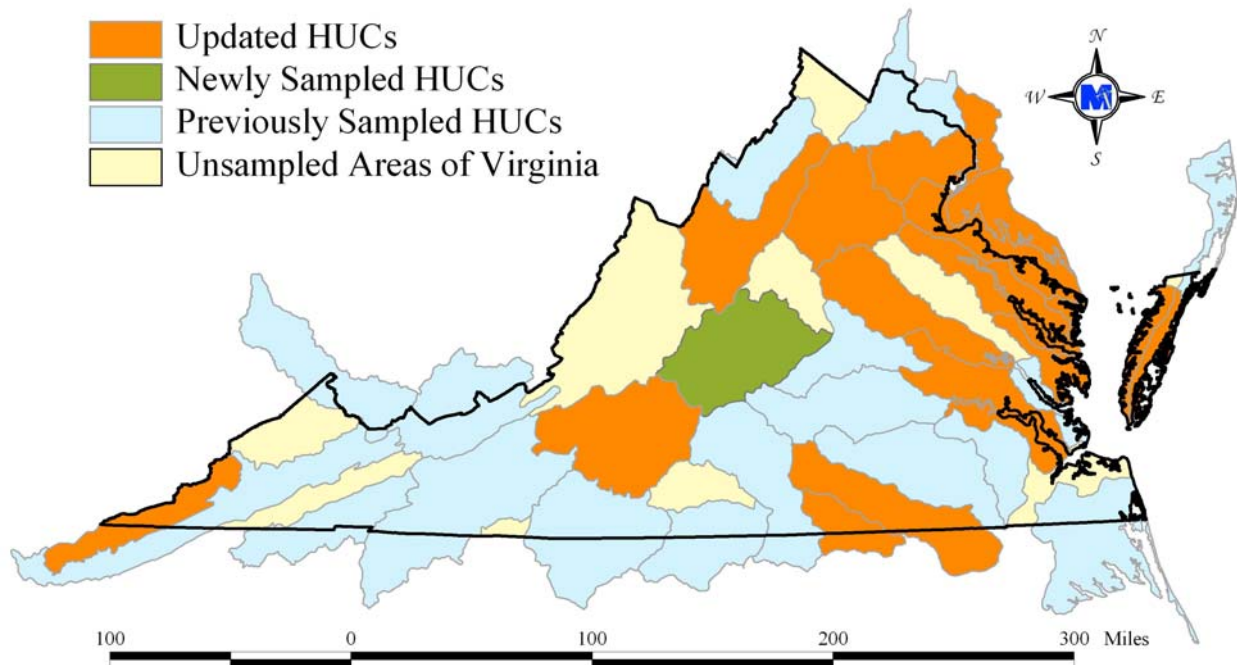
Figure 3.1   Locations of known-source sampling conducted to support this year's and previous years' BST analyses

Table 3.1   Source samples collected for BST library development.

Source	Source Species	Number of Samples Collected in Newly Sampled HUCs	Additional Samples Collected in Updated HUCs
Human	Septic Systems, Portable Toilets, …	15	5
Livestock	Dairy, Beef, Horse, Sheep, Broilers, Turkeys, Swine, Waste Storage Pits, …	15	5
Wildlife	Deer, Raccoon, Muskrat, Duck, Goose, …	15	5
Pets	Dogs & Cats	15	5
Total		60	20

3.2   Development of Known-Source Libraries

An appropriate known-source library was selected for each of the impairments to complete objective 2. A predictive model was developed from each library using logistic regression. A known-source library must be large enough to prevent an over-specified fit to the library. However, known-source responses to ARA analyses have been observed to vary geographically. The characteristics of this variance has not been well defined, so the regional libraries developed for this study were combined in a stepwise procedure and analyzed to measure the resulting specificity and the predictive accuracy of the combined libraries, as detailed in Section 4 of this document.

3.3   BST Analyses

For objective 3, water quality monitoring sites were identified and sampled by the granting agency (Figure 3.2 and Table 3.2). The contract began in July 2004, for many sites. At the conclusion of the study, most sites will have been sampled monthly for up to one year. Samples were received in the form of plates used in enumeration of *E. coli* concentrations. BST was run on bacteria isolated from these plates. Bacteria were analyzed using Hagedorn's ARA methodology, yielding the percentage of isolates classified as human, livestock, wildlife, and pets. Up to 24 bacterial isolates were

analyzed per sample, limited only by the number of isolates available from the enumeration process.
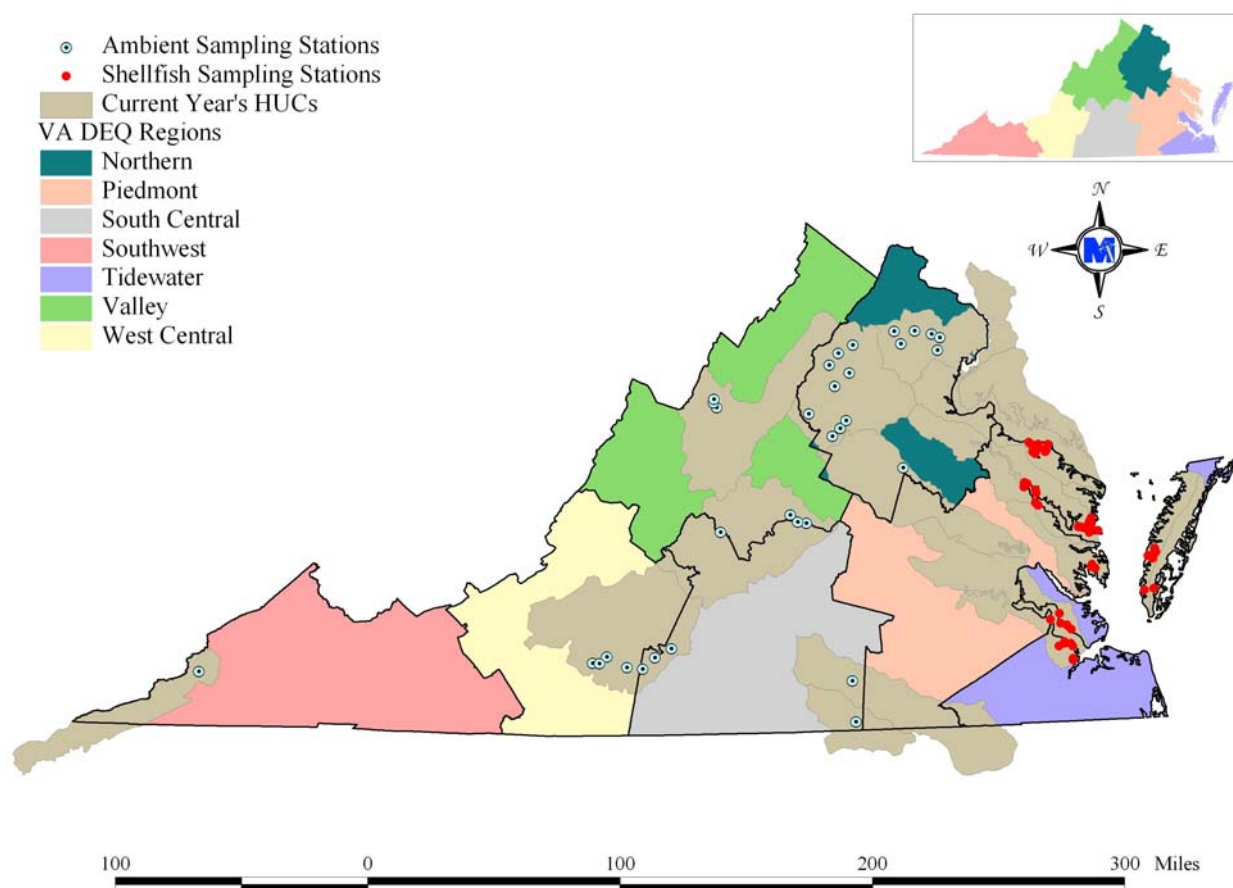
Figure 3.2 **Spatial distribution of impaired segments identified by region.**

Table 3.2   Distribution of stations sampled by VDH-DSS in support of this study.

Waterbody	Hydrologic Unit	BST Stations
Tabbs Creek	C01	1
Dymer Creek	C01	2
Indian Creek	C01	3
Antipoison Creek	C01	1
Little Oyster Creek	E26	1
Mosquito Creek	E26	1
Carter Creek	E26	3
Richardson Creek	E24	1
Totuskey Creek	E23	3
Wares Wharf	E24	4
Currioman Bay	A32	2
East River	C04	3
Nomini	A32	5
Lower Machodoc Creek	A32	2
Warwick River	G11	1
Mouth of Deep Creek	G11	1
Morrison's Creek	G11	1
Lower Machodoc Creek	A32	1
Skiffs Creek	G11	1
Cobham Bay/Lawnes Cr	G11	1
Pagan River	G11	2
Jones Creek	G11	1
Mouth of Beatty Creek	G11	1
Chuck Creek	G11	1
James River- Ballard's Marsh	G11	1
Brewer's Creek	G11	1
Holly Cove	C13	1
Nassawadox	C13	1
Westerhouse Creek	C13	2
Church Creek	C13	1
Warehouse Creek	C13	1
Kings Creek	C15	1
Oyster Harbor	D05	1

4. KNOWN-SOURCE LIBRARY DEVELOPMENT

As discussed in Section 3, a predictive model was developed from each library using logistic regression. The regional libraries developed for this study were combined in a stepwise procedure and analyzed to measure the resulting specificity and the predictive accuracy of the combined libraries. The specificity and predictive accuracy were assessed through three analyses. First, the ARCC was calculated for the library. Second, a randomization test was performed by randomly assigning source categories to samples and assessing the ARCC for the randomized library. Ten randomizations were performed and the results averaged. The expected result of randomization of four source categories is an ARCC of 25%, indicating a completely random result. Greater values for the randomized ARCC indicate a more specified model. Third, a jackknifing routine was conducted; where data from each whole fecal sample were individually withheld during development of the statistical model, then the model was tested for predictive accuracy on the withheld sample. In combining regional libraries a balance was sought between minimizing the randomized ARCC and maximizing the jackknifed ARCC. Table 4.1 shows the resulting analyses on the finalized libraries. Table 4.2 shows how the libraries were applied to the analysis of water samples by the HUC in which they were collected.

Table 4.1   Results of known-source library development.

Known-Source Library	Regional Libraries Included (by HUC)	ARCC (%)	Randomized ARCC (%)	Jackknifed ARCC (%)
2005-09	2070011+2080207	79%	38%	71%
2005-10	2080102+2080207	79%	38%	70%
2005-11	2080104+2080103+2070005+2080207	71%	36%	66%
2005-12	2080109+2060009+2080207	73%	36%	66%
2005-13	2080110+2060009+2080207	74%	37%	67%
2005-14	2080206+2080207	86%	39%	77%

Table 4.2   Known-source libraries associated with HUCs included in this study.

HUC	Known-Source Library
HUC 2070011	2005-09
HUC 2080102	2005-10
HUC 2080104	2005-11
HUC 2080109	2005-12
HUC 2080110	2005-13
HUC 2080206	2005-14

5. RESULTS

The results of the water quality analyses for VADEQ's 2004-2005 BST sampling in shellfish waters are reported in this section. The proportions reported are formatted to indicate statistical significance (*i.e.*, **BOLD** numbers indicate a statistically significant result). The statistical significance was determined through 2 tests. The first was based on the sample size. A z-test was used to determine if the proportion was significantly different from zero (alpha = 0.10). Second the rate of false positives was calculated for each source category in each library, and a proportion was not considered significantly different from zero unless it was greater than the false-positive rate plus three standard deviations.

5.1 Results for Piedmont Region

The results of the water quality analyses for VADEQ's Piedmont Region (Figure 5.1) are reported in the following tables. Table 5.1 indicates the number of samples analyzed in the 2004-2005 sampling phase. The results of the BST analysis are reported in Tables 5.2 through 5.35.
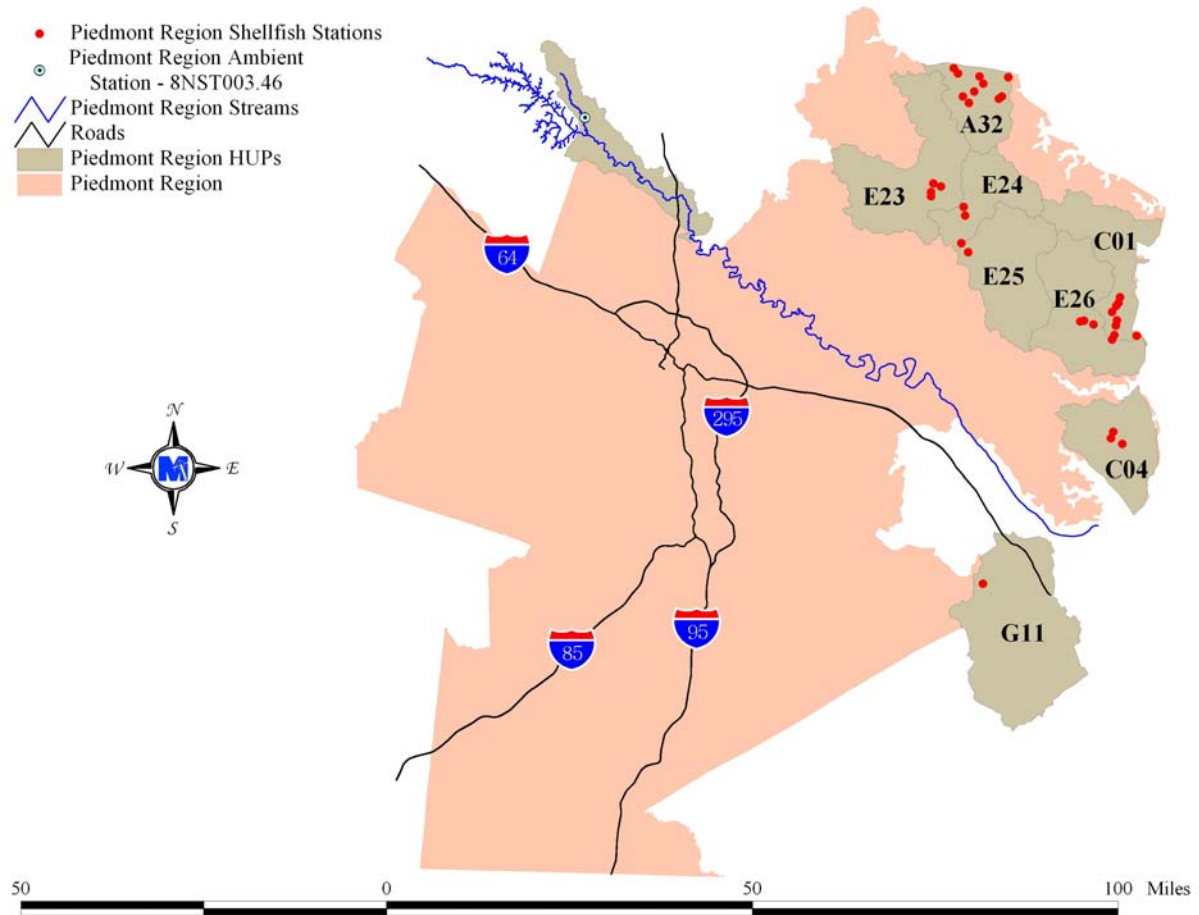
Figure 5.1   Bacterial sampling stations in VADEQ's Piedmont Region.

Table 5.1   **Summary of VDH-DSS bacterial sampling in VADEQ's Piedmont Region.**

Station Number	Station ID	DSS Area	HUP	County	Impairment	# Times Plates Received
1	4-11	4	A32	Westermoreland	Currioman Bay	12
2	4-14	4	A32	Westermoreland	Currioman Bay	12
3	4-23	4	A32	Westermoreland	Nomini	11
4	4-29.5	4	A32	Westermoreland	Nomini	12
5	4-30.4	4	A32	Westermoreland	Nomini	12
6	4-35	4	A32	Westermoreland	Nomini	12
7	4-38	4	A32	Westermoreland	Nomini	12
8	5-20	5	A32	Westermoreland	Lower Machodoc C	12
9	5-23	5	A32	Westermoreland	Lower Machodoc C	12
10	5-8Z	5	A32	Westermoreland	Lower Machodoc C	10
11	16-13	16	C01	Lancaster	Tabbs Creek	12
12	16-19B	16	C01	Lancaster	Dymer Creek	10
13	16-21A	16	C01	Lancaster	Dymer Creek	12
14	16-29B	16	C01	Lancaster	Indian Creek	12
15	16-30	16	C01	Lancaster	Indian Creek	12
16	16-34	16	C01	Northumberland	Indian Creek	11
17	17-8	17	C01	Lancaster	Antipoison Creek	12
18	18-5A	18	E26	Lancaster	Mosquito Creek	9
19	18-14	18	E26	Lancaster	Little Oyster Cr	10
20	20-11	20	E26	Lancaster	Carter Creek	9
21	20-13	20	E26	Lancaster	Carter Creek	11
22	20-15	20	E26	Lancaster	Carter Creek	10
23	25-17	25	E24	Richmond	Richardson Creek	12
24	25-3	25	E24	Richmond	Totuskey Creek	12
25	25A-7	25A	E23	Richmond	Totuskey Creek	12
26	25A-8	25A	E23	Richmond	Totuskey Creek	12
27	26-1	26	E24	Essex	Wares Wharf	11
28	26-2	26	E25	Essex	Wares Wharf	11
29	26A-5	26A	E23	Essex	Piscataway Creek	12
30	26A-9	26A	E23	Essex	Rappahannock River	12
31	41-13	41	C04	Mathews	East River	11
32	41-15	41	C04	Mathews	East River	11
33	41-8	41	C04	Mathews	East River	11
34	60-1	60	G11	Surry	Cobham Bay/Lawnes Creek	12

Table 5.2   Bacterial Source Tracking for Currioman Bay at Station 4-11.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
4-11	10/5/04	D3803	A32	24	0%	**100%**	0%	0%
4-11	11/4/04	D3886	A32	24	**12%**	**71%**	**17%**	0%
4-11	12/16/04	D4017	A32	8	12%	50%	0%	38%
4-11	1/3/05	D4040	A32	3	100%	0%	0%	0%
4-11	2/28/05	D4184	A32	24	0%	**42%**	4%	**54%**
4-11	3/31/05	D4259	A32	24	8%	**42%**	4%	**46%**
4-11	4/26/05	D4343	A32	24	**96%**	0%	4%	0%
4-11	5/11/05	D4378	A32	23	**26%**	**56%**	9%	9%
4-11	6/27/05	D4502	A32	24	0%	4%	**96%**	0%
4-11	7/25/05	D4609	A32	24	0%	**42%**	**58%**	0%
4-11	8/23/05	D4707	A32	24	**12%**	**12%**	**51%**	**25%**
4-11	9/7/05	D4745	A32	17	0%	6%	**88%**	6%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.3   Bacterial Source Tracking for Currioman Bay at Station 4-14.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
4-14	10/5/04	D3804	A32	24	8%	**84%**	0%	8%
4-14	11/4/04	D3887	A32	24	8%	**75%**	**17%**	0%
4-14	12/16/04	D4018	A32	13	15%	**69%**	8%	8%
4-14	1/3/05	D4041	A32	1	0%	0%	100%	0%
4-14	2/28/05	D4185	A32	24	0%	**29%**	**71%**	0%
4-14	3/31/05	D4260	A32	24	4%	**21%**	4%	**71%**
4-14	4/26/05	D4344	A32	24	**96%**	0%	4%	0%
4-14	5/11/05	D4379	A32	24	**37%**	**21%**	**17%**	**25%**
4-14	6/27/05	D4503	A32	24	0%	0%	**100%**	0%
4-14	7/25/05	D4610	A32	24	4%	**42%**	**54%**	0%
4-14	8/23/05	D4708	A32	23	9%	0%	**69%**	**22%**
4-14	9/7/05	D4746	A32	24	0%	8%	**92%**	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.4   Bacterial Source Tracking for Nomini at Station 4-23.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
4-23	10/5/04	D3805	A32	24	0%	**96%**	4%	0%
4-23	11/4/04	D3888	A32	24	**29%**	**59%**	0%	**12%**
4-23	12/16/04	D4019	A32	4	25%	0%	50%	25%
4-23	2/28/05	D4186	A32	7	14%	0%	0%	86%
4-23	3/31/05	D4261	A32	24	8%	**59%**	**25%**	8%
4-23	4/26/05	D4345	A32	24	**96%**	0%	0%	4%
4-23	5/11/05	D4380	A32	24	**38%**	**33%**	0%	**29%**
4-23	6/27/05	D4504	A32	24	0%	0%	**100%**	0%
4-23	7/25/05	D4611	A32	24	0%	**79%**	**21%**	0%
4-23	8/23/05	D4709	A32	24	4%	0%	**54%**	**42%**
4-23	9/7/05	D4747	A32	23	4%	4%	**83%**	9%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.5   Bacterial Source Tracking for Nomini at Station 4-29.5.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
4-29.5	10/5/04	D3806	A32	24	4%	**92%**	0%	4%
4-29.5	11/4/04	D3889	A32	24	**12%**	**59%**	12%	**17%**
4-29.5	12/16/04	D4020	A32	5	20%	20%	60%	0%
4-29.5	1/3/05	D4042	A32	1	0%	0%	0%	100%
4-29.5	2/28/05	D4187	A32	24	0%	0%	**46%**	**54%**
4-29.5	3/31/05	D4262	A32	24	4%	**76%**	8%	**12%**
4-29.5	4/26/05	D4346	A32	24	**92%**	8%	0%	0%
4-29.5	5/11/05	D4381	A32	24	0%	**67%**	**33%**	0%
4-29.5	6/27/05	D4505	A32	24	0%	**17%**	**75%**	8%
4-29.5	7/25/05	D4612	A32	24	0%	**79%**	**21%**	0%
4-29.5	8/23/05	D4710	A32	24	4%	**12%**	**76%**	8%
4-29.5	9/7/05	D4748	A32	24	4%	0%	**96%**	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.6   Bacterial Source Tracking for Nomini at Station 4-30.4.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
4-30.4	10/5/04	D3807	A32	24	**12%**	**80%**	8%	0%
4-30.4	11/4/04	D3890	A32	22	**14%**	**58%**	5%	**23%**
4-30.4	12/16/04	D4021	A32	16	**50%**	**44%**	6%	0%
4-30.4	1/3/05	D4043	A32	3	100%	0%	0%	0%
4-30.4	2/28/05	D4188	A32	24	4%	8%	**88%**	0%
4-30.4	3/31/05	D4263	A32	24	**12%**	**55%**	4%	**29%**
4-30.4	4/26/05	D4347	A32	24	**67%**	0%	**33%**	0%
4-30.4	5/11/05	D4382	A32	17	0%	**82%**	**18%**	0%
4-30.4	6/27/05	D4506	A32	24	**17%**	**71%**	12%	0%
4-30.4	7/25/05	D4613	A32	24	0%	**29%**	**71%**	0%
4-30.4	8/23/05	D4711	A32	24	8%	**12%**	**80%**	0%
4-30.4	9/7/05	D4749	A32	23	4%	4%	**92%**	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.7   Bacterial Source Tracking for Nomini at Station 4-35.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
4-35	10/5/04	D3808	A32	24	**21%**	**12%**	**17%**	**50%**
4-35	11/4/04	D3891	A32	14	**43%**	**29%**	7%	**21%**
4-35	12/16/04	D4022	A32	24	**29%**	**33%**	0%	**38%**
4-35	1/3/05	D4044	A32	3	33%	0%	0%	67%
4-35	2/28/05	D4189	A32	12	17%	**25%**	**41%**	17%
4-35	3/31/05	D4264	A32	24	**17%**	**75%**	0%	8%
4-35	4/26/05	D4348	A32	24	**46%**	0%	**54%**	0%
4-35	5/11/05	D4383	A32	24	**25%**	**29%**	**17%**	**29%**
4-35	6/27/05	D4507	A32	24	**29%**	**38%**	**33%**	0%
4-35	7/25/05	D4614	A32	24	0%	**46%**	**50%**	4%
4-35	8/23/05	D4712	A32	24	0%	0%	**100%**	0%
4-35	9/7/05	D4750	A32	22	9%	9%	**77%**	5%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.8   Bacterial Source Tracking for Nomini at Station 4-38.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
4-38	10/5/04	D3809	A32	24	**42%**	**12%**	**17%**	**29%**
4-38	11/4/04	D3892	A32	14	**29%**	0%	**21%**	**50%**
4-38	12/16/04	D4023	A32	24	**25%**	**29%**	4%	**42%**
4-38	1/3/05	D4045	A32	1	100%	0%	0%	0%
4-38	2/28/05	D4190	A32	22	**73%**	0%	9%	**18%**
4-38	3/31/05	D4265	A32	19	**16%**	**73%**	0%	11%
4-38	4/26/05	D4349	A32	24	**79%**	**17%**	0%	4%
4-38	5/11/05	D4384	A32	24	**29%**	**21%**	**25%**	**25%**
4-38	6/27/05	D4508	A32	24	0%	0%	**21%**	**79%**
4-38	7/25/05	D4615	A32	15	0%	**53%**	**47%**	0%
4-38	8/23/05	D4713	A32	12	0%	8%	**92%**	0%
4-38	9/7/05	D4751	A32	7	14%	0%	86%	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.9   Bacterial Source Tracking for Lower Machodoc Creek at Station 5-20.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
5-20	10/6/04	D3819	A32	24	8%	**54%**	**38%**	0%
5-20	11/3/04	D3901	A32	18	0%	**33%**	**67%**	0%
5-20	12/2/04	D3959	A32	24	8%	**42%**	0%	**50%**
5-20	1/4/05	D4047	A32	12	**33%**	17%	**42%**	8%
5-20	2/15/05	D4171	A32	24	4%	**42%**	**29%**	**25%**
5-20	3/17/05	D4222	A32	4	25%	0%	0%	75%
5-20	4/13/05	D4292	A32	24	**33%**	4%	**17%**	**46%**
5-20	5/12/05	D4386	A32	24	**33%**	**17%**	8%	**42%**
5-20	6/28/05	D4511	A32	24	**42%**	**50%**	0%	8%
5-20	7/12/05	D4542	A32	18	0%	12%	**44%**	**44%**
5-20	8/24/05	D4719	A32	24	0%	**21%**	**71%**	8%
5-20	9/26/05	D4830	A32	24	0%	**17%**	**79%**	4%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.10   Bacterial Source Tracking for Lower Machodoc Creek at Station 5-23.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
5-23	10/6/04	D3820	A32	24	4%	**17%**	**79%**	0%
5-23	11/3/04	D3902	A32	23	4%	**26%**	**70%**	0%
5-23	12/2/04	D3960	A32	24	8%	**12%**	0%	**80%**
5-23	1/4/05	D4048	A32	11	**64%**	**36%**	0%	0%
5-23	2/15/05	D4172	A32	7	57%	0%	14%	29%
5-23	3/17/05	D4223	A32	11	**55%**	0%	9%	**36%**
5-23	4/13/05	D4293	A32	24	8%	**17%**	8%	**67%**
5-23	5/12/05	D4387	A32	24	**17%**	**12%**	12%	**59%**
5-23	6/28/05	D4512	A32	24	**54%**	**25%**	0%	**21%**
5-23	7/12/05	D4543	A32	24	8%	8%	**67%**	**17%**
5-23	8/24/05	D4720	A32	20	0%	**30%**	**65%**	5%
5-23	9/26/05	D4831	A32	16	0%	6%	**94%**	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.11   Bacterial Source Tracking for Lower Machodoc Creek at Station 5-8Z.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
5-8Z	10/6/04	D3818	A32	23	**17%**	**30%**	**53%**	0%
5-8Z	11/3/04	D3900	A32	10	10%	**60%**	**30%**	0%
5-8Z	12/2/04	D3958	A32	24	**21%**	**63%**	4%	**12%**
5-8Z	1/4/05	D4046	A32	6	17%	17%	66%	0%
5-8Z	4/13/05	D4291	A32	19	5%	**85%**	5%	5%
5-8Z	5/12/05	D4385	A32	10	**70%**	20%	0%	10%
5-8Z	6/28/05	D4510	A32	24	0%	8%	**88%**	4%
5-8Z	7/12/05	D4541	A32	24	4%	8%	**63%**	**25%**
5-8Z	8/24/05	D4718 *	A32	24	0%	0%	**100%**	0%
5-8Z	9/26/05	D4829	A32	22	0%	**14%**	**86%**	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.
* Anomalies in the laboratory results may indicate improper handling of the filter plates prior to delivery to the laboratory.

Table 5.12   Bacterial Source Tracking for Tabbs Creek at Station 16-13.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
16-13	10/21/04	D3850	C01	24	**68%**	**12%**	12%	8%
16-13	11/8/04	D3920	C01	22	**14%**	**77%**	9%	0%
16-13	12/8/04	D3984	C01	22	**50%**	**36%**	0%	**14%**
16-13	1/19/05	D4087	C01	24	**55%**	**12%**	33%	0%
16-13	2/17/05	D4173	C01	24	0%	**62%**	0%	**38%**
16-13	3/21/05	D4231	C01	24	**33%**	0%	**63%**	4%
16-13	4/4/05	D4273	C01	24	**12%**	**84%**	4%	0%
16-13	5/17/05	D4399	C01	8	12%	0%	50%	38%
16-13	6/29/05	D4513	C01	14	7%	14%	14%	**65%**
16-13	7/27/05	D4623	C01	8	50%	25%	0%	25%
16-13	8/29/05	D4731	C01	15	**67%**	0%	**20%**	13%
16-13	9/13/05	D4776	C01	9	22%	**78%**	0%	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.13   Bacterial Source Tracking for Dymer Creek at Station 16-19B.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
16-19B	10/21/04	D3851	C01	24	**38%**	**62%**	0%	0%
16-19B	11/8/04	D3921	C01	24	**21%**	**17%**	**25%**	**37%**
16-19B	12/8/04	D3985	C01	4	0%	75%	0%	25%
16-19B	2/17/05	D4174	C01	7	0%	14%	0%	86%
16-19B	4/4/05	D4274	C01	24	**17%**	**79%**	4%	0%
16-19B	5/17/05	D4400	C01	24	**41%**	0%	**21%**	**38%**
16-19B	6/29/05	D4514	C01	24	0%	8%	12%	**80%**
16-19B	7/27/05	D4624	C01	6	17%	0%	0%	83%
16-19B	8/29/05	D4732	C01	10	**30%**	10%	0%	**60%**
16-19B	9/13/05	D4777	C01	2	50%	0%	0%	50%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.14   Bacterial Source Tracking for Dymer Creek at Station 16-21A.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
16-21A	10/21/04	D3852	C01	15	**33%**	**67%**	0%	0%
16-21A	11/8/04	D3922	C01	24	**33%**	4%	**33%**	**30%**
16-21A	12/8/04	D3986	C01	24	**63%**	**25%**	8%	4%
16-21A	1/19/05	D4088	C01	12	**42%**	**42%**	16%	0%
16-21A	2/17/05	D4175	C01	14	7%	**43%**	**21%**	**29%**
16-21A	3/21/05	D4232	C01	4	0%	0%	50%	50%
16-21A	4/4/05	D4275	C01	24	8%	**88%**	0%	4%
16-21A	5/17/05	D4401	C01	24	**42%**	4%	4%	**50%**
16-21A	6/29/05	D4515	C01	24	4%	8%	**21%**	**67%**
16-21A	7/27/05	D4625	C01	18	6%	6%	0%	**88%**
16-21A	8/29/05	D4733	C01	24	**54%**	**38%**	0%	8%
16-21A	9/13/05	D4778	C01	17	**18%**	**53%**	0%	**29%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.15   Bacterial Source Tracking for Indian Creek at Station 16-29B.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
16-29B	10/21/04	D3853	C01	24	**17%**	**25%**	**25%**	**33%**
16-29B	11/8/04	D3923	C01	17	12%	**41%**	**41%**	6%
16-29B	12/8/04	D3987	C01	24	8%	**71%**	4%	**17%**
16-29B	1/19/05	D4089	C01	24	**79%**	**17%**	4%	0%
16-29B	2/17/05	D4176	C01	7	14%	14%	0%	**72%**
16-29B	3/21/05	D4233	C01	14	**21%**	0%	**21%**	**58%**
16-29B	4/4/05	D4276	C01	24	**17%**	**75%**	0%	8%
16-29B	5/17/05	D4402	C01	24	**83%**	**17%**	0%	0%
16-29B	6/29/05	D4516	C01	24	8%	**12%**	**17%**	**63%**
16-29B	7/27/05	D4626	C01	17	**88%**	0%	12%	0%
16-29B	8/29/05	D4734	C01	19	**47%**	**16%**	0%	**37%**
16-29B	9/13/05	D4779	C01	19	**21%**	**26%**	0%	**53%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.16   Bacterial Source Tracking for Indian Creek at Station 16-30.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
16-30	10/21/04	D3854	C01	24	**25%**	**71%**	0%	4%
16-30	11/8/04	D3924	C01	14	**93%**	0%	0%	7%
16-30	12/8/04	D3988	C01	24	**29%**	**67%**	4%	0%
16-30	1/19/05	D4090	C01	12	**25%**	**58%**	17%	0%
16-30	2/17/05	D4177	C01	12	**58%**	17%	8%	17%
16-30	3/21/05	D4234	C01	6	0%	17%	0%	83%
16-30	4/4/05	D4277	C01	24	**21%**	**75%**	4%	0%
16-30	5/17/05	D4403	C01	15	**47%**	**53%**	0%	0%
16-30	6/29/05	D4517	C01	24	0%	**54%**	**17%**	**29%**
16-30	7/27/05	D4627	C01	15	13%	**27%**	0%	**60%**
16-30	8/29/05	D4735	C01	15	**40%**	**33%**	7%	**20%**
16-30	9/13/05	D4780	C01	11	**27%**	9%	9%	**55%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.17   Bacterial Source Tracking for Indian Creek at Station 16-34.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
16-34	10/21/04	D3855	C01	24	**25%**	**50%**	**17%**	8%
16-34	11/8/04	D3925	C01	15	**27%**	**59%**	7%	7%
16-34	12/8/04	D3989	C01	24	**29%**	**59%**	4%	8%
16-34	2/17/05	D4178	C01	24	4%	**63%**	0%	**33%**
16-34	3/21/05	D4235	C01	14	**29%**	**57%**	0%	14%
16-34	4/4/05	D4278	C01	24	**50%**	**46%**	4%	0%
16-34	5/17/05	D4404	C01	17	**82%**	6%	0%	12%
16-34	6/29/05	D4518	C01	24	**21%**	**54%**	0%	**25%**
16-34	7/27/05	D4628	C01	23	**30%**	**44%**	0%	**26%**
16-34	8/29/05	D4736	C01	22	0%	0%	9%	**91%**
16-34	9/13/05	D4781	C01	9	22%	22%	11%	**45%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.18   Bacterial Source Tracking for Antipoison Creek at Station 17-8.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
17-8	10/21/04	D3849	C01	24	**29%**	**71%**	0%	0%
17-8	11/8/04	D3926	C01	9	**89%**	11%	0%	0%
17-8	12/8/04	D3990	C01	22	**45%**	**23%**	9%	**23%**
17-8	1/19/05	D4091	C01	8	76%	12%	12%	0%
17-8	2/17/05	D4179	C01	15	**20%**	0%	**53%**	**27%**
17-8	3/21/05	D4236	C01	20	**50%**	**45%**	5%	0%
17-8	4/4/05	D4279	C01	24	**25%**	**67%**	8%	0%
17-8	5/17/05	D4405	C01	24	**71%**	4%	**17%**	8%
17-8	6/29/05	D4519	C01	20	**25%**	**65%**	5%	5%
17-8	7/27/05	D4629	C01	7	71%	0%	0%	29%
17-8	8/29/05	D4737	C01	22	0%	0%	0%	**100%**
17-8	9/13/05	D4782	C01	9	**44%**	**44%**	0%	12%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.19   Bacterial Source Tracking for Mosquito Creek at Station 18-5A.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
18-5A	11/18/04	D3933	E26	15	**39%**	7%	**27%**	**27%**
18-5A	12/21/04	D4024	E26	2	100%	0%	0%	0%
18-5A	1/20/05	D4092	E26	2	0%	100%	0%	0%
18-5A	4/18/05	D4306	E26	10	**40%**	**60%**	0%	0%
18-5A	5/2/05	D4354	E26	24	**96%**	0%	4%	0%
18-5A	6/15/05	D4477	E26	24	**17%**	**83%**	0%	0%
18-5A	7/28/05	D4630	E26	24	**12%**	**42%**	0%	**46%**
18-5A	8/15/05	D4652	E26	11	**55%**	**45%**	0%	0%
18-5A	9/12/05	D4771	E26	19	**32%**	**47%**	0%	**21%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.20   Bacterial Source Tracking for Little Oyster Creek at Station 18-14.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
18-14	11/18/04	D3934	E26	23	**30%**	**35%**	**35%**	0%
18-14	12/21/04	D4025	E26	8	25%	63%	12%	0%
18-14	1/20/05	D4093	E26	3	67%	33%	0%	0%
18-14	2/3/05	D4122	E26	6	50%	0%	17%	33%
18-14	4/18/05	D4307	E26	24	**12%**	**71%**	**17%**	0%
18-14	5/2/05	D4355	E26	24	**100%**	0%	0%	0%
18-14	6/15/05	D4478	E26	24	**29%**	**63%**	8%	0%
18-14	7/28/05	D4631	E26	24	**46%**	**33%**	0%	**21%**
18-14	8/15/05	D4653	E26	20	**20%**	**70%**	10%	0%
18-14	9/12/05	D4772	E26	24	**46%**	**29%**	0%	**25%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.21   Bacterial Source Tracking for Carter Creek at Station 20-11.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
20-11	11/18/04	D3935	E26	22	**45%**	**55%**	0%	0%
20-11	12/21/04	D4026	E26	24	**88%**	**12%**	0%	0%
20-11	1/20/05	D4094	E26	22	**63%**	0%	5%	**32%**
20-11	4/18/05	D4308	E26	7	71%	29%	0%	0%
20-11	5/2/05	D4356	E26	24	**21%**	0%	12%	**67%**
20-11	6/15/05	D4479	E26	24	4%	**41%**	**17%**	**38%**
20-11	7/28/05	D4632	E26	24	0%	4%	**29%**	**67%**
20-11	8/15/05	D4654	E26	24	**17%**	**29%**	**42%**	**12%**
20-11	9/12/05	D4773	E26	24	4%	0%	**54%**	**42%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.22   Bacterial Source Tracking for Carter Creek at Station 20-13.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
20-13	11/18/04	D3936	E26	8	0%	25%	12%	63%
20-13	12/21/04	D4027	E26	24	**84%**	4%	0%	**12%**
20-13	1/20/05	D4095	E26	2	50%	0%	0%	50%
20-13	2/3/05	D4123	E26	24	**25%**	**17%**	**29%**	**29%**
20-13	3/3/05	D4195	E26	6	0%	83%	0%	17%
20-13	4/18/05	D4309	E26	3	33%	67%	0%	0%
20-13	5/2/05	D4357	E26	24	0%	0%	0%	**100%**
20-13	6/15/05	D4480	E26	20	**30%**	**50%**	0%	**20%**
20-13	7/28/05	D4633	E26	5	20%	20%	20%	40%
20-13	8/15/05	D4655	E26	7	0%	100%	0%	0%
20-13	9/12/05	D4774	E26	4	0%	50%	25%	25%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.23   Bacterial Source Tracking for Carter Creek at Station 20-15.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
20-15	11/18/04	D3937	E26	12	0%	0%	0%	**100%**
20-15	12/21/04	D4028	E26	13	**62%**	**38%**	0%	0%
20-15	1/20/05	D4096	E26	4	100%	0%	0%	0%
20-15	2/3/05	D4124	E26	3	33%	0%	0%	67%
20-15	4/18/05	D4310	E26	1	100%	0%	0%	0%
20-15	5/2/05	D4358	E26	24	**42%**	**17%**	8%	**33%**
20-15	6/15/05	D4481	E26	24	**58%**	0%	0%	**42%**
20-15	7/28/05	D4634	E26	6	33%	0%	0%	67%
20-15	8/15/05	D4656	E26	12	0%	**75%**	**25%**	0%
20-15	9/12/05	D4775	E26	9	22%	**45%**	22%	11%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.24   Bacterial Source Tracking for Richardson Creek at Station 25-17.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
25-17	10/21/04	D3848	E24	24	**33%**	**59%**	4%	4%
25-17	11/4/04	D3899	E24	24	4%	**71%**	0%	**25%**
25-17	12/6/04	D3962	E24	24	**29%**	**38%**	**21%**	**12%**
25-17	1/4/05	D4050	E24	24	**38%**	8%	12%	**42%**
25-17	2/2/05	D4126	E24	24	**38%**	**46%**	4%	**12%**
25-17	3/16/05	D4225	E24	16	0%	12%	**44%**	**44%**
25-17	4/14/05	D4295	E24	24	12%	**50%**	**21%**	**17%**
25-17	5/16/05	D4392	E24	24	12%	8%	**17%**	**63%**
25-17	6/13/05	D4463	E24	24	**84%**	8%	0%	8%
25-17	7/14/05	D4545	E24	24	**21%**	**29%**	**38%**	**12%**
25-17	8/10/05	D4645	E24	24	**29%**	**25%**	**38%**	8%
25-17	9/8/05	D4753	E24	24	4%	**25%**	**71%**	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.25   Bacterial Source Tracking for Totuskey Creek at Station 25-3.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
25-3	10/21/04	D3847	E24	24	**38%**	**33%**	8%	**21%**
25-3	11/4/04	D3898	E24	23	**13%**	**83%**	0%	4%
25-3	12/6/04	D3961	E24	24	12%	**25%**	**21%**	**42%**
25-3	1/4/05	D4049	E24	10	**40%**	20%	20%	20%
25-3	2/2/05	D4125	E24	20	**35%**	**40%**	10%	**15%**
25-3	3/16/05	D4224	E24	14	0%	**21%**	0%	**79%**
25-3	4/14/05	D4294	E24	24	**33%**	**17%**	**25%**	**25%**
25-3	5/16/05	D4391	E24	24	12%	**17%**	**33%**	**38%**
25-3	6/13/05	D4462	E24	24	**38%**	4%	**41%**	**17%**
25-3	7/14/05	D4544	E24	24	**29%**	**21%**	**38%**	**12%**
25-3	8/10/05	D4644	E24	24	**38%**	**12%**	**38%**	**12%**
25-3	9/8/05	D4752	E24	24	**17%**	4%	**75%**	4%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.26   Bacterial Source Tracking for Totuskey Creek at Station 25A-7.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
25A-7	10/21/04	D3845	E23	22	0%	**23%**	9%	**68%**
25A-7	11/4/04	D3893	E23	20	0%	**45%**	5%	**50%**
25A-7	12/6/04	D3963	E23	24	**33%**	**12%**	4%	**51%**
25A-7	1/4/05	D4051	E23	12	17%	**58%**	**25%**	0%
25A-7	2/2/05	D4127	E23	24	**21%**	**50%**	**21%**	8%
25A-7	3/16/05	D4226	E23	7	0%	29%	0%	71%
25A-7	4/14/05	D4298	E23	24	**17%**	**58%**	4%	**21%**
25A-7	5/16/05	D4393	E23	24	**42%**	**33%**	8%	**17%**
25A-7	6/13/05	D4464	E23	24	**50%**	**33%**	0%	**17%**
25A-7	7/14/05	D4546	E23	24	0%	**29%**	**71%**	0%
25A-7	8/10/05	D4646	E23	24	8%	**25%**	**38%**	**29%**
25A-7	9/8/05	D4754	E23	24	12%	**33%**	**38%**	**17%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.27   Bacterial Source Tracking for Totuskey Creek at Station 25A-8.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
25A-8	10/21/04	D3846	E23	24	**46%**	**38%**	4%	**12%**
25A-8	11/4/04	D3894	E23	22	**14%**	**63%**	**23%**	0%
25A-8	12/6/04	D3964	E23	24	**17%**	8%	4%	**71%**
25A-8	1/4/05	D4052	E23	8	25%	12%	12%	51%
25A-8	2/2/05	D4128	E23	24	**50%**	**29%**	**17%**	4%
25A-8	3/16/05	D4227	E23	2	0%	0%	0%	100%
25A-8	4/14/05	D4299	E23	24	8%	**76%**	12%	4%
25A-8	5/16/05	D4394	E23	14	**72%**	**21%**	7%	0%
25A-8	6/13/05	D4465	E23	24	4%	**38%**	4%	**54%**
25A-8	7/14/05	D4547	E23	24	4%	0%	**75%**	**21%**
25A-8	8/10/05	D4647	E23	24	8%	**25%**	**46%**	**21%**
25A-8	9/8/05	D4755	E23	22	0%	5%	**86%**	9%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

RESULTS

Table 5.28   **Bacterial Source Tracking for Wares Wharf at Station 26-1.**

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
26-1	10/21/04	D3843	E24	18	0%	6%	6%	**88%**
26-1	11/4/04	D3897	E24	24	**21%**	**50%**	**17%**	12%
26-1	12/6/04	D3965	E24	21	**14%**	**19%**	**29%**	38%
26-1	1/4/05	D4053	E24	3	0%	0%	33%	67%
26-1	2/2/05	D4129	E24	1	0%	100%	0%	0%
26-1	4/14/05	D4300	E24	24	**38%**	**12%**	4%	**46%**
26-1	5/16/05	D4395	E24	24	**80%**	**12%**	8%	0%
26-1	6/13/05	D4466	E24	24	12%	**17%**	8%	**63%**
26-1	7/14/05	D4548	E24	24	0%	0%	**100%**	0%
26-1	8/10/05	D4648	E24	24	4%	0%	**88%**	8%
26-1	9/8/05	D4756	E24	22	0%	5%	**77%**	**18%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.29   **Bacterial Source Tracking for Wares Warf at Station 26-2.**

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
26-2	10/21/04	D3844	E25	24	0%	4%	**21%**	**75%**
26-2	12/6/04	D3966	E25	24	12%	8%	12%	**68%**
26-2	1/4/05	D4054	E25	2	0%	0%	100%	0%
26-2	2/2/05	D4130	E25	24	**25%**	**54%**	**21%**	0%
26-2	3/16/05	D4228	E25	2	0%	50%	0%	50%
26-2	4/14/05	D4301	E25	24	12%	**34%**	**25%**	**29%**
26-2	5/16/05	D4396	E25	24	**33%**	0%	**46%**	**21%**
26-2	6/13/05	D4467	E25	24	0%	**63%**	**25%**	**12%**
26-2	7/14/05	D4549	E25	24	**33%**	**29%**	**17%**	**21%**
26-2	8/10/05	D4649	E25	24	**29%**	0%	**54%**	**17%**
26-2	9/8/05	D4757	E25	24	0%	0%	**88%**	**12%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.30   Bacterial Source Tracking for Piscataway Creek at Station 26A-5.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
26A-5	10/21/04	D3841	E23	24	12%	0%	**21%**	**67%**
26A-5	11/4/04	D3895	E23	22	9%	**86%**	5%	0%
26A-5	12/6/04	D3967	E23	24	8%	**17%**	8%	**67%**
26A-5	1/4/05	D4055	E23	7	29%	43%	14%	14%
26A-5	2/2/05	D4131	E23	24	**25%**	**63%**	12%	0%
26A-5	3/16/05	D4229	E23	16	0%	6%	**25%**	**69%**
26A-5	4/14/05	D4296	E23	24	0%	**50%**	**17%**	**33%**
26A-5	5/16/05	D4397	E23	24	**46%**	0%	**33%**	**21%**
26A-5	6/13/05	D4468	E23	24	0%	**50%**	8%	**42%**
26A-5	7/14/05	D4550	E23	24	**75%**	0%	**25%**	0%
26A-5	8/10/05	D4650	E23	24	12%	0%	**88%**	0%
26A-5	9/8/05	D4758	E23	24	8%	4%	**76%**	**12%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.31   Bacterial Source Tracking for Rappahannock River at Station 26A-9.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
26A-9	10/21/04	D3842	E23	22	0%	5%	0%	**95%**
26A-9	11/4/04	D3896	E23	20	**15%**	**40%**	**20%**	**25%**
26A-9	12/6/04	D3968	E23	24	12%	**21%**	8%	**59%**
26A-9	1/4/05	D4056	E23	6	0%	66%	17%	17%
26A-9	2/2/05	D4132	E23	24	**55%**	**33%**	12%	0%
26A-9	3/16/05	D4230	E23	24	4%	8%	**67%**	**21%**
26A-9	4/14/05	D4297	E23	24	8%	**80%**	0%	**12%**
26A-9	5/16/05	D4398	E23	24	**21%**	**17%**	**33%**	**29%**
26A-9	6/13/05	D4469	E23	12	**83%**	0%	0%	17%
26A-9	7/14/05	D4551	E23	24	**21%**	**21%**	**41%**	**17%**
26A-9	8/10/05	D4651	E23	24	4%	4%	**75%**	**17%**
26A-9	9/8/05	D4759	E23	24	8%	**25%**	**63%**	4%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.32   Bacterial Source Tracking for East River at Station 41-13.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
41-13	11/9/04	D3928	C04	10	**60%**	0%	0%	**40%**
41-13	12/9/04	D3992	C04	24	**34%**	**25%**	12%	**29%**
41-13	1/25/05	D4104	C04	4	100%	0%	0%	0%
41-13	2/7/05	D4145	C04	2	50%	50%	0%	0%
41-13	3/7/05	D4203	C04	8	0%	0%	0%	100%
41-13	4/20/05	D4319	C04	24	8%	**51%**	8%	**33%**
41-13	5/4/05	D4366	C04	24	**25%**	**46%**	12%	**17%**
41-13	6/2/05	D4442	C04	24	0%	**96%**	0%	4%
41-13	7/18/05	D4572	C04	24	**17%**	**21%**	**33%**	**29%**
41-13	8/1/05	D4638	C04	24	8%	0%	**50%**	**42%**
41-13	9/14/05	D4789	C04	7	100%	0%	0%	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.33   Bacterial Source Tracking for East River at Station 41-15.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
41-15	11/9/04	D3929	C04	8	25%	50%	0%	25%
41-15	12/9/04	D3993	C04	21	**66%**	**29%**	0%	5%
41-15	1/25/05	D4105	C04	16	**19%**	**75%**	6%	0%
41-15	2/7/05	D4146	C04	7	86%	14%	0%	0%
41-15	3/7/05	D4204	C04	19	0%	0%	5%	**95%**
41-15	4/20/05	D4320	C04	24	8%	0%	4%	**88%**
41-15	5/4/05	D4367	C04	24	8%	**25%**	**50%**	**17%**
41-15	6/2/05	D4443	C04	24	**12%**	0%	4%	**84%**
41-15	7/18/05	D4573	C04	24	**29%**	8%	**38%**	**25%**
41-15	8/1/05	D4639	C04	24	8%	8%	**38%**	**46%**
41-15	9/14/05	D4790	C04	16	12%	**38%**	0%	**50%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.34   Bacterial Source Tracking for East River at Station 41-8.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
41-8	11/9/04	D3927	C04	14	**50%**	0%	0%	**50%**
41-8	12/9/04	D3991	C04	23	**65%**	**22%**	4%	9%
41-8	1/25/05	D4103	C04	3	67%	33%	0%	0%
41-8	2/7/05	D4144	C04	2	50%	50%	0%	0%
41-8	3/7/05	D4202	C04	4	0%	0%	0%	100%
41-8	4/20/05	D4318	C04	5	20%	60%	0%	20%
41-8	5/4/05	D4365	C04	24	**38%**	**46%**	8%	8%
41-8	6/2/05	D4441	C04	24	0%	**83%**	0%	**17%**
41-8	7/18/05	D4571	C04	24	**75%**	**21%**	0%	4%
41-8	8/1/05	D4637	C04	24	**12%**	**12%**	8%	**68%**
41-8	9/14/05	D4788	C04	6	83%	17%	0%	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.35   Bacterial Source Tracking for Cobham Bay/Lawnes Creek at Station 60-1.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
60-1	10/6/04	D3814	G11	12	17%	**83%**	0%	0%
60-1	11/8/04	D3919	G11	1	0%	100%	0%	0%
60-1	12/7/04	D3979	G11	24	**47%**	**12%**	12%	**29%**
60-1	1/5/05	D4067	G11	23	**30%**	**61%**	9%	0%
60-1	2/2/05	D4121	G11	24	**75%**	**17%**	0%	8%
60-1	3/7/05	D4207	G11	2	50%	0%	50%	0%
60-1	4/4/05	D4270	G11	24	**12%**	**42%**	**46%**	0%
60-1	5/3/05	D4364	G11	19	**47%**	11%	**42%**	0%
60-1	6/1/05	D4440	G11	5	20%	60%	20%	0%
60-1	7/13/05	D4540	G11	16	**31%**	**31%**	**31%**	7%
60-1	8/16/05	D4668	G11	17	12%	**58%**	**18%**	12%
60-1	9/13/05	D4783	G11	20	**25%**	**15%**	5%	**55%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

5.2   Results for Tidewater Region

The results of the water quality analyses for VADEQ's Tidewater Region (Figure 5.2) are reported in the following tables. Table 5.36 indicates the number of samples analyzed in the 2004-2005 sampling phase. The results of the BST analysis are reported in Tables 5.37 through 5.55.
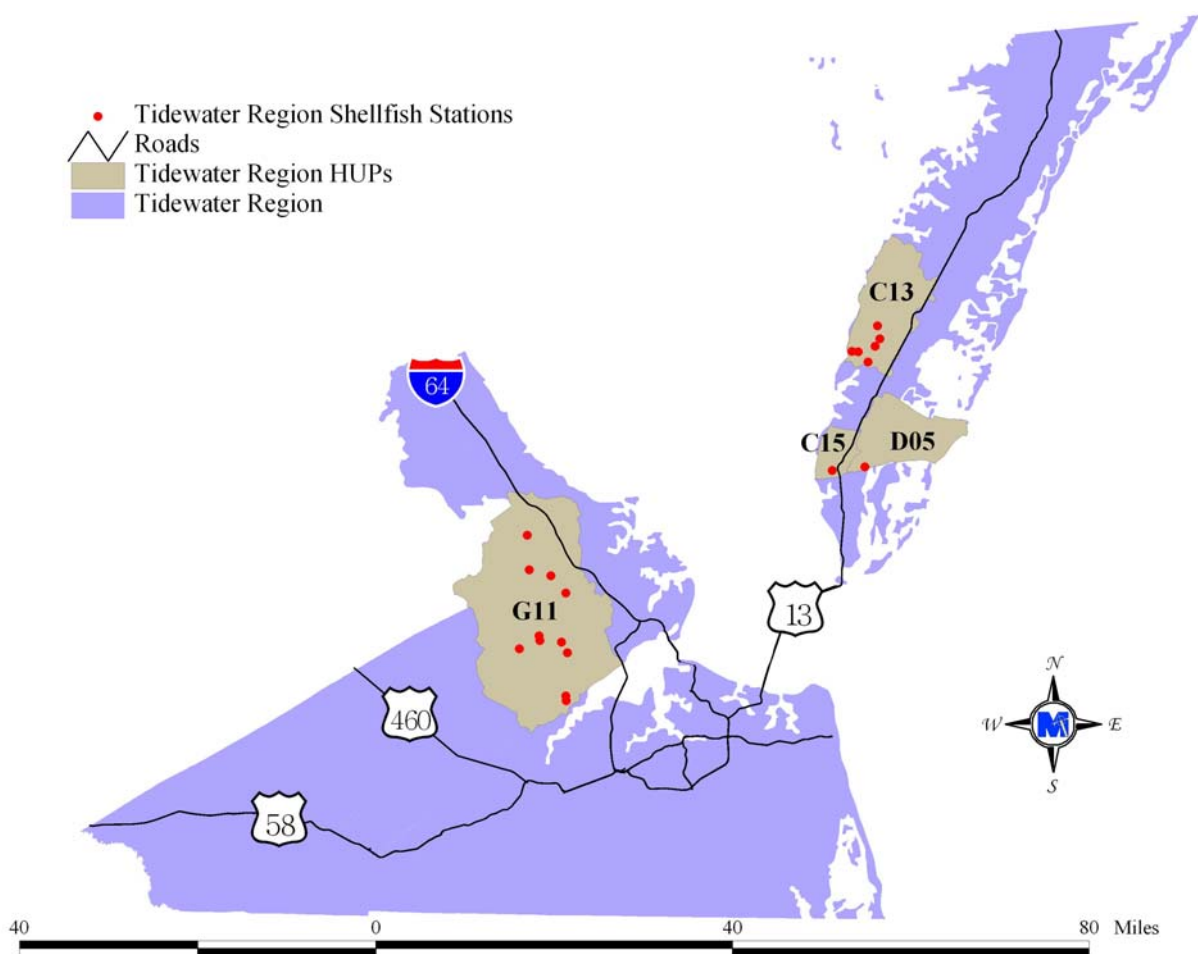
Figure 5.2   Bacterial sampling stations in VADEQ's Tidewater Region.

Table 5.36   Summary of VDH-DSS bacterial sampling in VADEQ's Tidewater Region.

Station Number	Station ID	DSS Area	HUP	County	Impairment	# Times Plates Received
1	85-13B	85	C13	Northampton	Holly Cove	10
2	85-16	85	C13	Northampton	Nassawadox	11
3	85-3	85	C13	Northampton	Westerhouse Creek	11
4	85-5	85	C13	Northampton	Westerhouse Creek	11
5	85-5D	85	C13	Northampton	Church Creek	11
6	85-9.6E	85	C13	Northampton	Warehouse Creek	10
7	88-22	88	C15	Northampton	Kings Creek	12
8	94-3W	94	D05	Northampton	Oyster Harbor	11
9	58-10	58	G11	Newport News	Warwick River	12
10	58-2A	58	G11	Newport News	Mouth of Deep Creek	12
11	58-M77	58	G11	Newport News	Morrison's Creek	11
12	59-AA78	59	G11	Newport News	Skiffs Creek	10
13	61-13	61	G11	Surry	Pagan River	12
14	61-15	61	G11	Isle of Wight	Jones Creek	12
15	61-3B	61	G11	Isle of Wight	Mouth of Beatty Creek	12
16	61-4	61	G11	Surry	Pagan River	12
17	62-10	62	G11	Isle of Wight	Chuck Creek	11
18	62-14	62	G11	Isle of Wight	James River- Ballard's Marsh	11
19	62-9.1A	62	G11	Isle of Wight	Brewer's Creek	11

Table 5.37   Bacterial Source Tracking for Holly Cove at Station 85-13B.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
85-13B	10/25/04	D3875	C13	21	**43%**	**43%**	5%	9%
85-13B	11/10/04	D3910	C13	5	100%	0%	0%	0%
85-13B	12/9/04	D4009	C13	7	14%	58%	14%	14%
85-13B	2/7/05	D4139	C13	5	80%	0%	0%	20%
85-13B	4/19/05	D4325	C13	24	**33%**	**17%**	**38%**	**12%**
85-13B	5/3/05	D4372	C13	23	**69%**	9%	**22%**	0%
85-13B	6/2/05	D4446	C13	24	**88%**	0%	8%	4%
85-13B	7/18/05	D4591	C13	23	0%	**17%**	**83%**	0%
85-13B	8/17/05	D4689	C13	24	0%	4%	**88%**	8%
85-13B	9/14/05	D4795	C13	24	**21%**	**21%**	**54%**	4%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.38   Bacterial Source Tracking for Nassawadox at Station 85-16.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
85-16	10/25/04	D3876	C13	18	**61%**	**22%**	0%	**17%**
85-16	11/10/04	D3911	C13	6	83%	17%	0%	0%
85-16	12/9/04	D4010	C13	19	**63%**	11%	**26%**	0%
85-16	2/7/05	D4140	C13	2	50%	50%	0%	0%
85-16	3/7/05	D4243	C13	1	100%	0%	0%	0%
85-16	4/19/05	D4326	C13	23	**17%**	**13%**	**44%**	**26%**
85-16	5/3/05	D4373	C13	24	**84%**	8%	8%	0%
85-16	6/2/05	D4447	C13	24	0%	**29%**	**71%**	0%
85-16	7/18/05	D4592	C13	24	4%	**12%**	**84%**	0%
85-16	8/17/05	D4690	C13	24	4%	8%	**67%**	**21%**
85-16	9/14/05	D4796	C13	7	14%	29%	57%	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.39   **Bacterial Source Tracking for Westerhouse Creek at Station 85-3.**

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
85-3	11/9/04	D3912	C13	24	**54%**	**38%**	8%	0%
85-3	12/8/04	D4005	C13	14	**86%**	14%	0%	0%
85-3	1/6/05	D4072	C13	15	**47%**	**20%**	**33%**	0%
85-3	2/16/05	D4181	C13	10	**30%**	20%	0%	**50%**
85-3	3/21/05	D4237	C13	24	**84%**	4%	12%	0%
85-3	4/4/05	D4272	C13	13	15%	**85%**	0%	0%
85-3	5/2/05	D4369	C13	6	50%	50%	0%	0%
85-3	6/1/05	D4449	C13	24	12%	8%	**80%**	0%
85-3	7/14/05	D4586	C13	22	**14%**	**14%**	5%	**67%**
85-3	8/15/05	D4684	C13	23	9%	0%	**30%**	**61%**
85-3	9/13/05	D4792	C13	9	11%	22%	**67%**	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.40   **Bacterial Source Tracking for Westerhouse Creek at Station 85-5.**

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
85-5	11/9/04	D3913	C13	21	**66%**	**29%**	0%	5%
85-5	12/8/04	D4006	C13	15	**40%**	**40%**	0%	**20%**
85-5	1/6/05	D4073	C13	24	**88%**	4%	8%	0%
85-5	2/16/05	D4182	C13	5	0%	0%	0%	100%
85-5	3/21/05	D4238	C13	10	**50%**	**40%**	10%	0%
85-5	4/4/05	D4271	C13	24	**33%**	**67%**	0%	0%
85-5	5/2/05	D4368	C13	16	**31%**	**57%**	12%	0%
85-5	6/1/05	D4448	C13	24	0%	**46%**	**54%**	0%
85-5	7/14/05	D4585	C13	23	4%	0%	0%	**96%**
85-5	8/15/05	D4685	C13	24	4%	**12%**	**72%**	**12%**
85-5	9/13/05	D4791	C13	24	4%	**12%**	**76%**	8%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.41   Bacterial Source Tracking for Church Creek at Station 85-5D.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
85-5D	10/25/04	D3873	C13	23	**35%**	**61%**	4%	0%
85-5D	11/10/04	D3908	C13	2	0%	100%	0%	0%
85-5D	12/9/04	D4007	C13	14	**21%**	**72%**	0%	7%
85-5D	2/7/05	D4138	C13	1	0%	100%	0%	0%
85-5D	3/7/05	D4241	C13	3	33%	67%	0%	0%
85-5D	4/19/05	D4323	C13	12	**67%**	8%	**25%**	0%
85-5D	5/3/05	D4370	C13	14	**72%**	**21%**	0%	7%
85-5D	6/2/05	D4444	C13	24	**58%**	0%	0%	**42%**
85-5D	7/18/05	D4589	C13	23	**13%**	**13%**	**65%**	9%
85-5D	8/17/05	D4687	C13	24	0%	4%	**33%**	**63%**
85-5D	9/14/05	D4793	C13	24	4%	**12%**	**84%**	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.42   Bacterial Source Tracking for Warehouse Creek at Station 85-9.6E.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
85-9.6E	10/25/04	D3874	C13	21	**38%**	**57%**	0%	5%
85-9.6E	11/10/04	D3909	C13	7	100%	0%	0%	0%
85-9.6E	12/9/04	D4008	C13	17	**64%**	**18%**	6%	12%
85-9.6E	3/7/05	D4242	C13	2	100%	0%	0%	0%
85-9.6E	4/19/05	D4324	C13	8	50%	38%	12%	0%
85-9.6E	5/3/05	D4371	C13	23	**53%**	4%	**43%**	0%
85-9.6E	6/2/05	D4445	C13	24	**71%**	4%	0%	**25%**
85-9.6E	7/18/05	D4590	C13	24	0%	**25%**	**75%**	0%
85-9.6E	8/17/05	D4688	C13	23	**14%**	0%	**43%**	**43%**
85-9.6E	9/14/05	D4794	C13	8	12%	12%	76%	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.43   Bacterial Source Tracking for Kings Creek at Station 88-22.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
88-22	10/26/04	D3877	C15	24	**63%**	**29%**	0%	8%
88-22	11/8/04	D3907	C15	22	**54%**	**27%**	14%	5%
88-22	12/8/04	D4004	C15	21	**47%**	**24%**	**24%**	5%
88-22	1/10/05	D4075	C15	10	0%	0%	0%	**100%**
88-22	2/18/05	D4183	C15	24	0%	0%	**33%**	**67%**
88-22	3/22/05	D4240	C15	24	**92%**	4%	0%	4%
88-22	4/19/05	D4321	C15	20	**15%**	**35%**	**25%**	**25%**
88-22	5/4/05	D4374	C15	17	**88%**	0%	12%	0%
88-22	6/1/05	D4450	C15	24	12%	8%	**51%**	**29%**
88-22	7/14/05	D4587	C15	24	12%	**17%**	**71%**	0%
88-22	8/15/05	D4683	C15	24	0%	4%	12%	**84%**
88-22	9/29/05	D4839	C15	24	4%	**17%**	**79%**	0%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.44   Bacterial Source Tracking for Oyster Harbor at Station 94-3W.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
94-3W	10/26/04	D3878	D05	24	**21%**	**41%**	0%	**38%**
94-3W	11/8/04	D3914	D05	18	6%	**94%**	0%	0%
94-3W	12/8/04	D4003	D05	24	0%	**59%**	**33%**	8%
94-3W	1/10/05	D4074	D05	24	4%	**38%**	**29%**	**29%**
94-3W	3/22/05	D4239	D05	2	0%	0%	0%	100%
94-3W	4/19/05	D4322	D05	12	0%	**59%**	**33%**	8%
94-3W	5/4/05	D4375	D05	20	**40%**	**25%**	**25%**	10%
94-3W	6/1/05	D4451	D05	24	**17%**	**17%**	**41%**	**25%**
94-3W	7/14/05	D4588	D05	24	0%	**12%**	**80%**	8%
94-3W	8/15/05	D4686	D05	24	0%	**58%**	**38%**	4%
94-3W	9/29/05	D4840	D05	24	0%	8%	**54%**	**38%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.45   Bacterial Source Tracking for Warwick River at Station 58-10.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
58-10	10/6/04	D3816	G11	NVI	NVI	NVI	NVI	NVI
58-10	11/8/04	D3916	G11	8	0%	100%	0%	0%
58-10	12/7/04	D3976	G11	2	100%	0%	0%	0%
58-10	1/5/05	D4064	G11	3	0%	0%	33%	67%
58-10	2/2/05	D4118	G11	22	**81%**	**14%**	5%	0%
58-10	3/7/05	D4206	G11	8	38%	0%	38%	24%
58-10	4/4/05	D4267	G11	24	**25%**	**41%**	**17%**	**17%**
58-10	5/3/05	D4361	G11	17	**29%**	**29%**	**36%**	6%
58-10	6/1/05	D4437	G11	24	0%	**100%**	0%	0%
58-10	7/13/05	D4537	G11	9	0%	11%	11%	**78%**
58-10	8/16/05	D4665	G11	24	**12%**	**17%**	**38%**	**33%**
58-10	9/13/05	D4785	G11	24	**46%**	4%	8%	**42%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.46   Bacterial Source Tracking for Mouth of Deep Creek at Station 58-2A.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
58-2A	10/6/04	D3815	G11	6	17%	50%	0%	33%
58-2A	11/8/04	D3915	G11	8	0%	100%	0%	0%
58-2A	12/7/04	D3975	G11	23	**48%**	**30%**	0%	**22%**
58-2A	1/5/05	D4063	G11	5	60%	20%	20%	0%
58-2A	2/2/05	D4117	G11	6	66%	17%	0%	17%
58-2A	3/7/05	D4205	G11	2	0%	0%	50%	50%
58-2A	4/4/05	D4266	G11	24	**33%**	**21%**	**17%**	**29%**
58-2A	5/3/05	D4360	G11	9	**33%**	22%	**45%**	0%
58-2A	6/1/05	D4436	G11	8	12%	63%	0%	25%
58-2A	7/13/05	D4536	G11	5	0%	0%	0%	100%
58-2A	8/16/05	D4664	G11	15	7%	**53%**	13%	**27%**
58-2A	9/13/05	D4784	G11	11	**36%**	0%	0%	**64%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Bacterial Source Tracking Analyses to Support Virginia's TMDLs

Table 5.47   Bacterial Source Tracking for Morrison's Creek at Station 58-M77.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
58-M77	10/6/04	D3817	G11	3	67%	33%	0%	0%
58-M77	11/8/04	D3917	G11	4	50%	50%	0%	0%
58-M77	12/7/04	D3977	G11	18	**28%**	**22%**	11%	**39%**
58-M77	1/5/05	D4065	G11	8	0%	0%	25%	75%
58-M77	2/2/05	D4119	G11	4	100%	0%	0%	0%
58-M77	4/4/05	D4268	G11	10	0%	0%	**80%**	20%
58-M77	5/3/05	D4362	G11	6	17%	66%	17%	0%
58-M77	6/1/05	D4438	G11	8	0%	100%	0%	0%
58-M77	7/13/05	D4538	G11	6	0%	33%	50%	17%
58-M77	8/16/05	D4666	G11	24	**21%**	**33%**	8%	**38%**
58-M77	9/13/05	D4786	G11	1	0%	0%	0%	100%

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.48   Bacterial Source Tracking for Skiffs Creek at Station 59-AA78.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
59-AA78	11/8/04	D3918	G11	7	29%	42%	29%	0%
59-AA78	12/7/04	D3978	G11	24	**46%**	**29%**	0%	**25%**
59-AA78	1/5/05	D4066	G11	17	12%	**70%**	**18%**	0%
59-AA78	2/2/05	D4120	G11	1	100%	0%	0%	0%
59-AA78	4/4/05	D4269	G11	24	**33%**	**17%**	**42%**	8%
59-AA78	5/3/05	D4363	G11	3	0%	33%	67%	0%
59-AA78	6/1/05	D4439	G11	2	0%	50%	50%	0%
59-AA78	7/13/05	D4539	G11	20	5%	**30%**	**40%**	**25%**
59-AA78	8/16/05	D4667	G11	24	0%	**12%**	**33%**	**55%**
59-AA78	9/13/05	D4787	G11	22	**23%**	**41%**	9%	**27%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.49   Bacterial Source Tracking for Pagan River at Station 61-13.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
61-13	10/25/04	D3867	G11	24	**25%**	**42%**	0%	**33%**
61-13	11/22/04	D3947*	G11	24	**100%**	0%	0%	0%
61-13	1/19/05	D4082	G11	24	**25%**	**29%**	**42%**	4%
61-13	2/7/05	D4149	G11	19	**74%**	**21%**	0%	5%
61-13	3/21/05	D4249	G11	14	**21%**	**65%**	14%	0%
61-13	4/19/05	D4313	G11	15	**54%**	0%	**33%**	13%
61-13	5/18/05	D4408*	G11	24	**100%**	0%	0%	0%
61-13	6/16/05	D4472	G11	24	**79%**	**17%**	4%	0%
61-13	7/27/05	D4618	G11	10	0%	**50%**	**30%**	20%
61-13	8/29/05	D4723	G11	5	20%	20%	20%	40%
61-13	9/26/05	D4834	G11	24	4%	**42%**	8%	**46%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.
* Anomalies in the laboratory results may indicate improper preparation of the media prior to delivery to the laboratory.

Table 5.50   Bacterial Source Tracking for Jones Creek at Station 61-15.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
61-15	10/25/04	D3868	G11	24	**16%**	**42%**	0%	**42%**
61-15	11/22/04	D3948*	G11	24	**100%**	0%	0%	0%
61-15	1/19/05	D4083	G11	22	**36%**	**36%**	**23%**	5%
61-15	2/7/05	D4150	G11	6	67%	0%	0%	33%
61-15	3/21/05	D4250	G11	7	29%	42%	29%	0%
61-15	4/19/05	D4314	G11	24	**29%**	8%	0%	**63%**
61-15	5/18/05	D4409*	G11	24	**100%**	0%	0%	0%
61-15	6/16/05	D4473	G11	24	**71%**	**21%**	8%	0%
61-15	7/27/05	D4619	G11	6	0%	67%	0%	33%
61-15	8/29/05	D4724	G11	22	9%	0%	**23%**	**68%**
61-15	9/26/05	D4835	G11	24	**17%**	**12%**	**21%**	**50%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.
* Anomalies in the laboratory results may indicate improper preparation of the media prior to delivery to the laboratory.

Table 5.51   Bacterial Source Tracking for Mouth of Beatty Creek at Station 61-3B.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
61-3B	10/25/04	D3865	G11	24	**38%**	**25%**	**33%**	4%
61-3B	11/22/04	D3945	G11	24	**88%**	0%	12%	0%
61-3B	1/19/05	D4080	G11	11	**27%**	18%	18%	**37%**
61-3B	2/7/05	D4147	G11	1	100%	0%	0%	0%
61-3B	3/21/05	D4247	G11	5	20%	60%	20%	0%
61-3B	4/19/05	D4311	G11	24	**33%**	**38%**	**21%**	8%
61-3B	5/18/05	D4406	G11	12	**42%**	17%	8%	**33%**
61-3B	6/16/05	D4470	G11	24	**33%**	**25%**	**42%**	0%
61-3B	7/27/05	D4616	G11	14	0%	14%	0%	**86%**
61-3B	8/29/05	D4721	G11	23	9%	4%	9%	**78%**
61-3B	9/26/05	D4832	G11	18	11%	**28%**	11%	**50%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.

Table 5.52   Bacterial Source Tracking for Pagan River at Station 61-4.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
61-4	10/25/04	D3866	G11	24	**42%**	4%	**46%**	8%
61-4	11/22/04	D3946*	G11	24	**100%**	0%	0%	0%
61-4	1/19/05	D4081	G11	24	**17%**	**38%**	**33%**	**12%**
61-4	2/7/05	D4148	G11	5	60%	0%	0%	40%
61-4	3/21/05	D4248	G11	7	57%	43%	0%	0%
61-4	4/19/05	D4312	G11	16	**45%**	**31%**	12%	12%
61-4	5/18/05	D4407*	G11	11	**100%**	0%	0%	0%
61-4	6/16/05	D4471	G11	24	**71%**	**21%**	4%	4%
61-4	7/27/05	D4617	G11	7	43%	14%	0%	43%
61-4	8/29/05	D4722	G11	7	0%	14%	29%	57%
61-4	9/26/05	D4833	G11	24	**12%**	**33%**	**17%**	**38%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.
* Anomalies in the laboratory results may indicate improper preparation of the media prior to delivery to the laboratory.

Table 5.53   **Bacterial Source Tracking for Chuck Creek at Station 62-10.**

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
62-10	10/25/04	D3870	G11	24	**12%**	**76%**	4%	8%
62-10	11/22/04	D3950*	G11	24	**100%**	0%	0%	0%
62-10	12/21/04	D4037	G11	24	**92%**	8%	0%	0%
62-10	1/19/05	D4085	G11	21	**33%**	**57%**	10%	0%
62-10	2/7/05	D4152	G11	3	67%	33%	0%	0%
62-10	3/22/05	D4245	G11	22	5%	**95%**	0%	0%
62-10	4/19/05	D4316	G11	24	0%	**25%**	**17%**	**58%**
62-10	5/18/05	D4411*	G11	24	**100%**	0%	0%	0%
62-10	6/16/05	D4475	G11	24	**92%**	8%	0%	0%
62-10	7/27/05	D4621	G11	16	**26%**	12%	**31%**	**31%**
62-10	8/29/05	D4726	G11	12	8%	8%	**25%**	**59%**
62-10	9/26/05	D4837	G11	24	0%	4%	0%	**96%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.
* Anomalies in the laboratory results may indicate improper preparation of the media prior to delivery to the laboratory.

Table 5.54   **Bacterial Source Tracking for James River – Ballard's Marsh at Station 62-14.**

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
62-14	10/25/04	D3871	G11	17	**29%**	**47%**	**18%**	6%
62-14	11/22/04	D3951*	G11	14	**100%**	0%	0%	0%
62-14	12/21/04	D4038	G11	24	**88%**	0%	12%	0%
62-14	1/19/05	D4086	G11	11	**64%**	**27%**	9%	0%
62-14	2/7/05	D4153	G11	2	50%	50%	0%	0%
62-14	3/22/05	D4246	G11	3	100%	0%	0%	0%
62-14	4/19/05	D4317	G11	7	0%	43%	43%	14%
62-14	5/18/05	D4412	G11	24	**88%**	8%	4%	0%
62-14	6/16/05	D4476	G11	24	**67%**	**25%**	8%	0%
62-14	7/27/05	D4622	G11	7	14%	58%	14%	14%
62-14	8/29/05	D4727	G11	24	**25%**	**12%**	**21%**	**42%**
62-14	9/26/05	D4838	G11	23	0%	0%	0%	**100%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.
* Anomalies in the laboratory results may indicate improper preparation of the media prior to delivery to the laboratory.

Table 5.55   Bacterial Source Tracking for Brewer's Creek at Station 62-9.1A.

Station ID	Date of Sample	Lab ID	HUP ID	Number of Isolates	Wildlife	Human	Livestock	Pet
62-9.1A	10/25/04	D3869	G11	24	**12%**	**76%**	0%	**12%**
62-9.1A	11/22/04	D3949*	G11	24	**100%**	0%	0%	0%
62-9.1A	12/21/04	D4036	G11	22	**41%**	**45%**	**14%**	0%
62-9.1A	1/19/05	D4084	G11	23	**44%**	**26%**	**26%**	4%
62-9.1A	2/7/05	D4151	G11	5	80%	0%	20%	0%
62-9.1A	3/22/05	D4244	G11	24	**17%**	**79%**	4%	0%
62-9.1A	4/19/05	D4315	G11	24	**17%**	**17%**	0%	**66%**
62-9.1A	5/18/05	D4410	G11	24	**83%**	**17%**	0%	0%
62-9.1A	6/16/05	D4474	G11	24	**42%**	**50%**	8%	0%
62-9.1A	7/27/05	D4620	G11	13	0%	**38%**	0%	**62%**
62-9.1A	8/29/05	D4725	G11	11	9%	0%	18%	**73%**
62-9.1A	9/26/05	D4836	G11	24	**21%**	0%	0%	**79%**

BOLD type indicates a statistically significant value.
NVI – No viable isolates.
* Anomalies in the laboratory results may indicate improper preparation of the media prior to delivery to the laboratory.

6. DISCUSSION

Results of the 2004-2005 VADEQ BST program have been presented in this report. The ARCCs achieved during the library development stage are acceptable and there does not appear to be a high level of over-fitting. Based on the sample size targeted in each sample (*i.e.*, 24 isolates), there is 90% confidence that the proportions measured in each sample are within 15% of the actual proportions in the sampled population (*i.e.,* all bacteria in the stream at the time of sampling). Because a fixed-frequency sampling scheme was used, samples are not biased toward a particular flow regime and can therefore be combined to estimate the actual proportions contributed by the different sources over the entire year with greater precision (*i.e.*, 90% confidence that the estimate is within 5% of the actual proportions). Additionally, the statistical analyses applied to determine a significant difference from zero give a good indication of presence and absence of each source in each sample. All of these data are valuable for use in improving public awareness of the problem, improving model calibration/validation, and providing a more equitable allocation of loads to source classes.

In spite of the high quality of the data collected, care should be taken in using these data. These data represent, at most, 12 instantaneous observations at each station and may not be representative of long-term conditions. The hydrologic conditions during this period may not reflect either average or critical conditions. Additionally, the dynamics of the bacterial community are not well understood, so care should be taken in extrapolating from the in-stream condition to activities in the watershed. As with any other monitoring program, the data should not be viewed in a vacuum. Local knowledge of the sources involved, historical water quality records, and the hydrologic conditions during sampling should all be considered in any interpretation of this data.

REFERENCES

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APPENDIX A

Bacterial Source Tracking Analyses supplemental Report

Table A.1 **False-positive and correct classification rates for eight BST libraries developed in support of VADEQ's Phase-III BST Program.**

Library	False-Positive Rates				Rate of Correct Classification			
	Wildlife	Human	Livestock	Pet	Wildlife	Human	Livestock	Pet
2005-09	9%	4%	11%	5%	67%	84%	82%	82%
2005-10	7%	3%	13%	6%	69%	91%	76%	81%
2005-11	10%	6%	14%	8%	59%	78%	75%	73%
2005-12	10%	6%	13%	7%	62%	80%	79%	73%
2005-13	9%	7%	12%	3%	65%	79%	81%	71%
2005-14	6%	.9%	10%	2%	77%	95%	88%	83%

Table A.2 **Species sampled for 6 libraries developed in support of VADEQ's Phase-III BST Program.**

Source Category	Species*	2005 Library Number					
		09	10	11	12	13	14
Human	Human	X	X	X	X	X	X
Livestock	Beef	X	X	X	X	X	X
	Dairy	X	X	X	X	X	X
	Donkey			X			
	Goat			X			
	Horse	X	X	X	X	X	X
	Llama						
	Poultry	X	X	X	X	X	X
	Sheep			X			
	Swine	X	X	X	X	X	X
Pet	Cat	X	X	X	X	X	X
	Dog	X	X	X	X	X	X
	Rabbit - Domestic						
Wildlife	Bear	X	X	X	X	X	X
	Bobcat			X			
	Coyote			X			
	Deer	X	X	X	X	X	X
	Duck			X			
	Fox	X	X	X	X	X	X
	Goose	X	X	X	X	X	X
	Muskrat	X		X	X	X	X
	Opossum			X			
	Otter	X	X	X	X	X	X
	Pigeon						
	Rabbit	X	X	X			
	Raccoon	X	X	X	X	X	X
	Skunk	X	X	X	X	X	X
	Squirrel	X	X	X	X	X	X
	Wild Turkey		X				X
	Wildlife - Avian	X			X		
	Wildlife - Unknown				X		X

*Sources identified for each library indicates that at least one sample were collected within the geographic regions listed for that library.